THE USE OF NITRATES AND NITRITES IN MEAT CURING AND PRESERVATION

BY

CARL JOHN DE BOER

B.S., University of Illinois, 1935
M.S., Rutgers University, 1937

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
BACTERIOLOGY IN THE GRADUATE SCHOOL
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THE USE OF NITRATES AND NITRITES IN MEAT CURING AND PRESERVATION

1. INTRODUCTION:

Less is known about the preservative powers of sodium nitrate and sodium nitrite in meat curing than about their ability to impart the characteristic color to cured meats. They have in general been used largely for the latter purpose. The few experiments, results of which have been reported, on a possible preservative action, have been carried out with these salts separately, or in mixtures, in liquid media and not in meat itself. Nitrate was first used but since this had to be reduced to nitrite before it could function as a color fixative, the suggestion was made that the latter might be added as such to the curing solution in order to save time. The investigation, results of which are reported at this time, concerned the preservative effect of sodium nitrate and sodium nitrite.

2. EXPERIMENTAL TECHNIQUE:

Fresh raw lean pork was ground in a sterile meat chopper. Various quantities of sodium nitrate and nitrite, separately and in mixtures, were added to a 500-gram portion of meat and thoroughly mixed in a sterile mortar. To some portions 3 per cent of cerelose were added in addition to nitrates and nitrites while others were inoculated with known numbers of spores of *Clostridium botulinum* and cells of *Staphylococcus citreus*. The meat was then packed into sterile flasks and stored at 3.3°C. (38°F.). Samples were prepared in duplicate and some in triplicate.

Bacteriological analyses as wel as quantitive determinations of nitrates, nitrites and proteolysis were made at 10 and/or 15 day intervals. All bacteriological analyses, aerobic and anaerobic, were made on nutrient agar using an incubation temperature of 37°C. Samples were weighed into tared flasks containing glass beads, and after additions of sterile water, were shaken thoroughly. Guinea pigs were used to determine

whether or not toxin was formed by *Clostridium botulinum*. Approximately 10 grams of meat were macerated with 20 cc. of sterile water to produce a heavy suspension, 1 cc. of which was fed to each animal.

The growth suppressive action of nitrates and nitrites on various types of organisms isolated from meat was determined. Various concentrations were added to nutrient broth and adjusted to pH 7.0, whereupon it was tubed and sterilized. Suspensions of the organisms were made in physiological salt solution. Two drops of the suspension were added to each tube containing 10 cc. of the broth. Incubation temperatures of 3.3°, 22°, and 37°C. were employed and growth determined by nitrate reduction and subculturing.

3. RESULTS

Sodium nitrate in concentrations up to 2 per cent was unable to prevent spoilage of meat for more than several weeks when stored at 3.3°C. (38°F.). Amounts up to 3 per cent showed no preservative action in meat inoculated with *Clostridium botulinum* using inspection, organoleptic analyses and the Sorensen formol titration as criteria of preservation and quality. Formation of nitrites from nitrates in this case occurred too slowly to suppress spoilage.

Sodium nitrite, on the other hand, in concentrations varying from 0.05 to 0.2 per cent showed good preservative qualities for meat when stored at 3.3°C. (38°F.). Samples kept as free as possible from outside contamination were in good condition after 1 year of storage. However, inoculation of meat with *Clstridium botulinum* and *Staphylococcus citreus* reduced slightly the preservative power of sodium nitrite in the above mentioned concentrations.

Curing mixtures consisting of 0.03 percent sodium nitrite, 0.165 percent sodium nitrate and 4.0 percent sodium chloride showed good preservative qualities in meat stored at 3.3°C. (38°F.). Inoculation of meat with *Clostridium botulinum* reduced the preservative power. Addition of 3 percent cerelose increases considerably the preservative qualities of the mixture.

Toxicity tests with guinea pigs were made on meat inoculated with *Clostridium botulinum* and preserved with various amounts of nitrates, nitrites and curing mixture. No toxin formation was indicated by animal feeding tests except in two instances in which the animals died with typical symptoms of botulism. In these two cases the meat had been preserved with 0.05 and 0.1 percent sodium nitrite respectively. Two different factors may be involved, a destructive action of nitrites on botulinum toxin a problem now under study and an antagonistic effect of nitrite on *Clostridium botulinum.*

4. CONCLUSION:

1. Sodium nitrite showed excellent preservative qualities for meat especially at curing cellar temperature 3.3°C. (38°F.). Amounts as low as from 0.05 to 0.2 per cent were effective.

2. Use of sodium nitrite in the curing mixture had a distinct advantage over sodium nitrate or mixed curing solutions because of its marked preservative properties and the ability to control more easily the nitrite content of cured meat.

3. Inoculation of meat preserved with amounts of sodium nitrite varying from 0.05 to 0.3 per cent with pure cultures of *Clostridium botulinum* and *Staphylococcus citreus* interfered somewhat with the preservative qualities of the nitrite when the samples were stored at 3.3°C. (38°F.). This was due to the proteolytic ability of these organisms added in such large numbers.

4. Outside contamination also decreased the preservative qualities of nitrites. Molds, constituting the chief form of contamination, reduced nitrites further and thus lowered their concentration.

5. The red color of meat preserved with nitrite begins to appear after approximately 3 weeks storage at 3.3°C. (38°F.). However, it is unstable unless provided with a continuous supply of nitrites in excess of that quantity originally required for its formation. A higher storage temperature also favors a more rapid development of the red color in meat in the pres-

ence of the same amounts of curing salts used at 3.3°C. (38°F.).

6. Sodium nitrate was a less satisfactory preservative for meat stored at curing room temperature at 3.3°C. ,38°F.) than sodium nitrite. Inoculation of meat with *Clostridium botulinum* diminished the preservative power further. Amounts up to 3 per cent did not prevent spoilage. Outside contamination affects the preservative power of nitrates to a lesser extent than nitrites.

7. Formation of nitrites from nitrates takes place too slowly to suppress spoilage. The immediate presence of sufficient quantities of nitrites (from 300 to 400 parts per million) is essential.

8. Curing mixtures such as recommended by the Bureau of Animal Industry have excellent preservative qualities on meat stored at 3.3°C. (38°F.). An increase in the amount of sodium nitrate from ½ to 1 ounce per 100 pounds of meat would improve the preservative power.

9. Sugar added to meat increases the preservative action of curing mixtures apparently by protein sparing action and increase in acidity (lowering of the pH.).

10. Sodium nitrite and sodium nitrate cannot always be relied upon to inhibit *Clostridium botulinum,* if the inoculum is heavy. The results of this investigation, however, would indicate that they would exert strong protective action with a light inoculation.

11. Pigment forming staphylococci were generally found present in fresh meat.

12. The observation of Haines[1] that slime formation is due to a small Gram-negative, nonspore-forming, short rod was confirmed.

13. The Sorensen Formol titration was used for detection of proteolysis and found satisfactory within certain limits.

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1. Haines, R. B. (1933). The Bacterial Flora Developing on Stored Meat, especially with Regard to "Slimy Meat". Jour. Hyg. Cambridge, *33,* 175.

VITA

The writer was born October 12, 1909, in Westerbur, Friesland. He attended public schools at Groode and Doornum and received his secondary education at Noorden and the Carteret High School, Carteret, New Jersey. In 1935 he received his degree of Bachelor of Science from the University of Illinois. From 1935 to 1937 he was graduate assistant at Rutgers University and received the degree of Master of Science in 1937, continuing his work there until 1938. In the fall of 1939 he entered the Graduate School of the University of Illinois devoting his full time to graduate study.

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